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NUMERICAL SIMULATION OF LEGUMES INTERACTION IN THE NIGER DELTA ECOLOGICAL REGION OF NIGERIA

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ABSTRACT

Crude oil spill is a serious and multi dimensional problem in Nigeria especially in the Niger Delta ecological region where crude oil exploration is at its peak. In this presentation,we have utilized a sound numerical simulation algorithm to derive the conditions under which a legally -binding control related policy is necessary in order to mitigate the endemic Niger Delta polluted environmental issue. The implication of this present analysis if implemented will have several benefits for the Nigerian sustainable

development formulation and is capable to revive the national economy.Numerical simulation of the growth of two legumes maize and cow pea in this ecological region was carried out and the numerical scheme used to predict the simultaneous effect of the changes in the intrinsic growth rate and the intra- competition coefficient parameter value on the type of stability .

INTRODUCTION

The Lotka Volterra equations were initially suggested to describe the interaction of biological species competing for the same resources (Lotka , 1956), and then applied to display parasitic and symbiotic relations or emerging and declining competitors, allowing for an intuitive understanding of the factors that drive co-evolution (Bazykin, 1998). Later interesting analogies between Biological ecology and technological development were drawn and several researchers started to use the equations to model competing technologies, since then the model has attracted considerable attention in the technology diffusion areas (Bharagava, 1998; Porter et al, 1991)

2.0 MATHEMATICAL FORMULATION

In the use of Lotka-Volterra equations as technological substitution model, we make two essential assumptions. The first one is that two technologies in the analysis should be related to each other, and competing for the limited resources.

$$\frac{dx_2(t)}{dt} = \frac{a_2 x_2}{k_2}(k_2 - x_2 - \alpha_1 x_1) \tag{1}$$

This is the multi- parameter model of Lotka Volterra type, which our discussions are centred on.

It can be observed that this system of equations has nine parameters:

$$a_1, k_1, a_2, k_2, \alpha_1, \alpha_2, x_1(t), x_2(t) and T.$$

2.1 LINEARIZATION OF AN ARBITRARY STEADY STATE SOLUTION.

By Hartman Grobman theorem which justifies the linear approximation around equilibrium point. Eka-kaa (2009) have shown that $F(x_{1e}, x_{2e})$ and G $G(x_{1e}, x_{2e})$ are both continuous and partially differentiable at an arbitrary steady state (x_{1e}, x_{2e}). We obtained four steady state solutions. For

$$(x_{1e}, x_{2e}) = \left(\frac{k_1 - \alpha_2 k_2}{1 - \alpha_1 \alpha_2}, \frac{k_2 - \alpha_1 k_1}{1 - \alpha_1 \alpha_2} \right)$$

$$J = \left(\frac{1}{1-\alpha_1\alpha_2}\right)\begin{pmatrix} \frac{-a_1}{k_1}(k_1-\alpha_2 k_2) & \frac{-a_1\alpha_2}{k_1}(k_1-\alpha_2 k_2) \\ -\frac{a_2\alpha_2}{k_2}(k_2-\alpha_1 k_1) & \frac{-a_2}{k_2}(k_2-\alpha_1 k_1) \end{pmatrix}$$

$$\lambda_1 = -\frac{a_1}{k_1(1-\alpha_1\alpha_2)}(k_1-\alpha_2 k_2) and \lambda_2 = -\frac{a_2}{k_2(1-\alpha_1\alpha_2)}(k_2-\alpha_1 k_1)$$

We have shown that the unique positive co-existence steady-state solution is .

3.0 RESULTS AND DISCUSSION

In this section, we present the results of our sensitivity analysis for group 1, group 2 and group 3 . Using **MATLAB** software
3.1 Presentation of results for group 1.
The group 1 parameters and their values are:
$a = 0.12, d = 0.12, x_1(0) = 1, x_2(0) = 2$ and $T = 10$ years.

We observed here that the intrinsic growth rate of maize is most sensitive, closely followed by the intrinsic growth rate for cowpea. Starting population of cowpea is the least important.

3.2 Presentation of results for group 2. The group 2 parameters values for this group are:

$b = 0.012, e = 0.012, x_1(0) = 1, x_2(0) = 2$ and $T = 10$ years.

We observed that the intra-specific competition coefficient of cowpea is more sensitive whereas the starting population for maize is the least sensitive. The intra-specific competition coefficient of cowpea is most sensitive , closely followed by the intra-specific competition coefficient for maize, whereas the starting population for maize is again least sensitive.

3.3 Presentation of results for group 3.

In this section, we present the result of our sensitivity analysis on the inter specific competition coefficient with starting populations and duration growth.

These are the values of the model parameters used:

$c = 0.00482, f = 0.0096, x_1(0) = 1, x_2(0) = 2$ and $T = 10$ years.

We observed that the inter-specific competition coefficient of coepea is more sensitive whereas the starting population for cowpea is the least sensitive.

In this group, the inter-specific competition coefficient for cowpea is most sensitive, followed by the duration of growth, T while the starting population for maize is the least sensitive closely followed by the starting populations of cowpea and inter- specific competition coefficient of maize. Tables, 1,2,3 below represent the result of the sensitivity analysis carried on the effect of oil spillage on both crops using the MATLAB software.

Table 1: **Effect of oil spillage on cowpea.**

Number of iteration	T	solution trajectory (y_1)
1	50	3.103859268057664
2	50	7.813676187424645
3	50	13.823262775164817
4	50	17.730181581904482
5	50	19.292398983035486
⋮	⋮	⋮
25	50	19.999716147491210
26	50	19.999447360181733
27	50	19.999048691087740
28	50	19.998164146290275
29	50	19.998164146290772
30	50	19.999426138082935

The graph is represented below

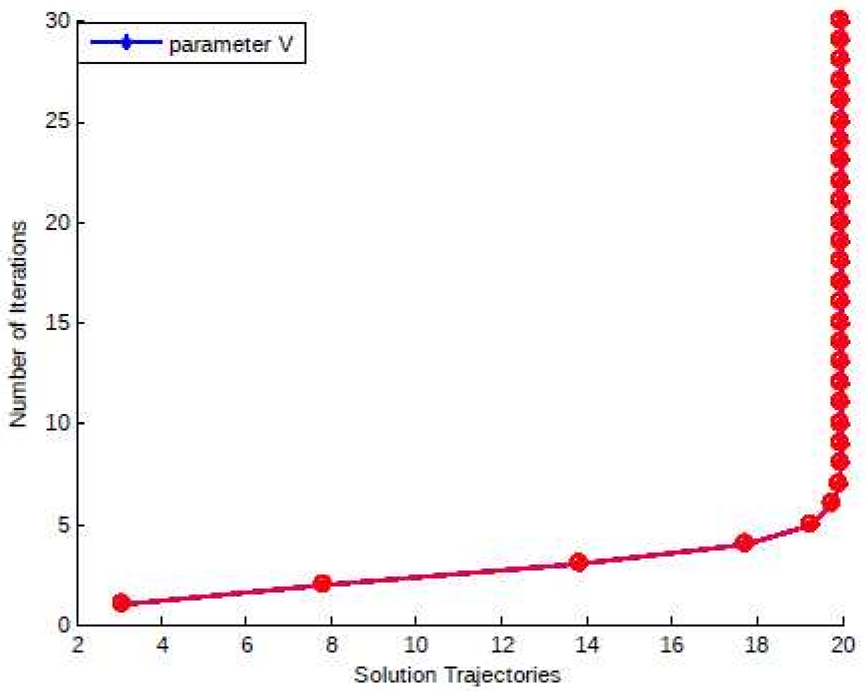

Fig. 1:Graph of the impact of oil spillage on the growth of cowpea

Table 2: **Effect of oil spillage on the growth of maize.**

Number of iteration	T	solution trajectory (y_2)
1	50	3.10385926805766 4
2	50	7.81367618742464 6
3	50	13.823262775164817
4	50	17.730181581904482
5	50	19.292398983035486
⋮	⋮	⋮
25	50	19.999716147490926
26	50	19.999447360181765
27	50	19.999048691087811
28	50	19.998164146290275
29	50	19.993211010674344
30	50	19.999426138082846

The above data is represented in fig. 2 below

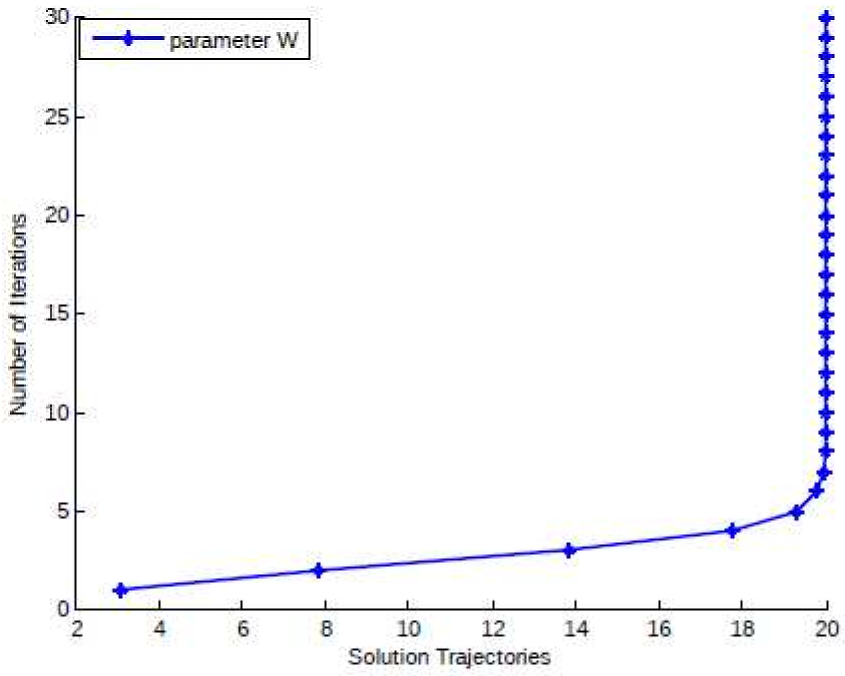

Fig 2:Graph of the impact of oil spillage on the growth of maize

Table 3: Effect of oil spillage on the the growth of cowpea and maize.

Number of iteration	solution trajectory of (y_1)	solution trajectory $(y$
1	3.103859268057664	3.103859268057664
2	7.813676187424645	7.813676187424646
3	13.823262775164817	13.82326277516481
4	17.730181581904482	17.73018158190448
5	19.292398983035486	19.29239898303548
⋮	⋮	⋮
25	19.999716147490926	19.99971614749121
26	19.999447360181765	19.99944736018173
27	19.999048691087811	19.99904869108774
28	19.998164146290275	19.99816414629077
29	19.993211010674344	19.99942613808293
30	19.999426138082846	19 .99942613808284

The above data is represented in fig.3 below

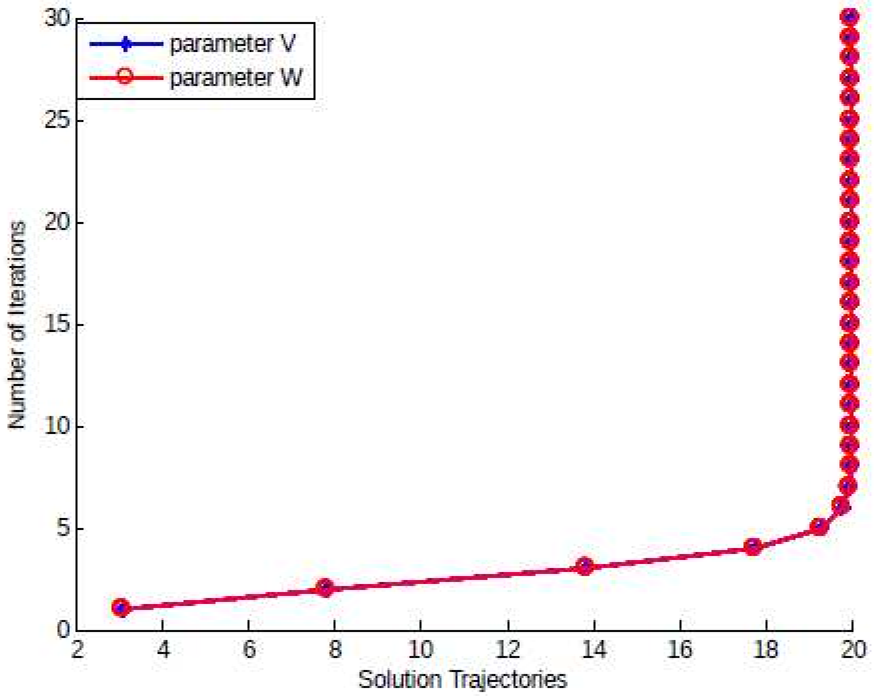

Fig.3:Graph of the impact of oil spillage on the growth of both crops

CONCLUSION

In this seminar, we have used the technique of sensitivity analysis to obtain the dominant or most sensitive parameters and the least sensitive parameters. The results obtained in this seminar, imply that crude oil spillage has adverse effect on the growth of cowpea and maize in the Niger Delta Ecological region of Nigeria. The result of this paper also add to a call for a total clean up in this region to stop the further degradation of the ecosystem. These observations are consistent with the current standard method of Ekaka-a (2009) in another Mathematical ecology context.